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(54) Gas delivery device

(57) A gas delivery device (1,6) comprises an inlet (3,12) for gas and two sheets (4,7,8) of woven, knitted or non-woven fibres arranged as a double layer. At least one of the sheets (4,7,8) has a region which is gas permeable to allow gas to permeate out of the device (1,6) when it is inflated. The device (1,6) may be used in a number of applications where gas delivery is required, such as to regulate the temperature of foodstuffs.

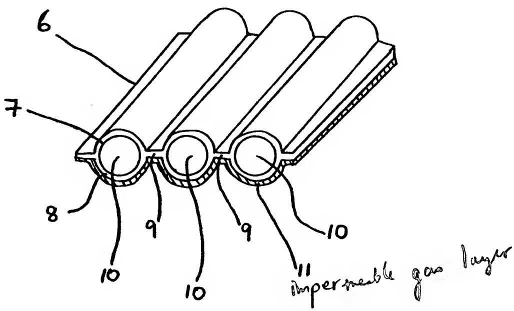

FIG. 2

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Description

This invention relates to a gas delivery device and to a method of delivering gas using the device.

The controlled delivery of gases is important in many technical fields. For example, temperature regulation by air conditioning is based on the delivery or air of a predetermined temperature into a room. Also, many chemical reactions require the delivery of gas into a reaction vessel and it is often desirable to have the gas provided as a fine dispersion of small bubbles into a liquid reaction mixture in order to maximise the rate of the reaction.

It is known that large enclosed spaces, such as exist in factories, can be heated by blowing hot air into an extended tube of fabric located near to their ceilings. The hot air permeates through the fabric and thereby heats the surrounding air inside the enclosed space. Since the body of fabric into which the hot air is blown is large and tubular, there is no direction of the hot air towards a particular location. Indeed, the very purpose of the arrangement is to ensure that hot air is emitted in all directions to give uniform heating of the surroundings.

GB-A-2146114 describes the use of cool air to regulate the temperature of a vehicle seat. The air is provided to the inside of a seat having an apparently conventional seat cover with a relatively high gas permeability of 200 to 1000 $cm^3/cm^2/s$. The cavity for the air is provided by a rigid frame structure which makes this system inflexible and relevant only to this specific type of application. Also, this high level of porosity makes even distribution of the cool air over the whole of the seat cover practically impossible.

There exists a need for a gas delivery system which is capable of delivering a uniform flow of gas in a defined direction at a predetermined rate but which can be made relatively light and versatile and is inexpensive. The present invention provides such a device.

Accordingly, the present invention provides a gas delivery device comprising an inlet for gas and two sheets of woven, knitted or non-woven fibres arranged as a double layer, at least one of the sheets having a portion which is gas permeable and the sheets being joined such that at least a part of the region between the sheets is capable of being inflated by gas directed through the inlet and, when inflated, of allowing the gas to permeate out of the device through the gas permeable sheet or sheets.

The sheets may be of woven, knitted or non-woven fibres but are preferably woven. The terms woven, knitted or non-woven, as used herein, cover all methods of constructing an article from fibres, threads or yarn. The fibres may be of ceramic material, which is particularly appropriate when the device is used in a high temperature environment (e.g., greater than 250°C) but are preferably of organic polymeric material such as polyamides (e.g., nylon), aramids (e.g., Kevlar[R]), polypropylene, polyester, acrylics (e.g., polyacrylate or polymethacrylate), cellulose or any other material which may be produced as a fibre. The fabric preferably has a weight of from 50 to 300 g/m^2.

The sheets may be made by conventional means well-known in the art. They may be formed as a roll of fabric which is subsequently cut to the desired lengths. The double layer arrangement of the sheets may be achieved by forming each sheet separately and then joining them by, for example, stitching, sealing, heat fusing or using an adhesive, at suitable places along the length of the double layer sheet. Alternatively, the two sheets may be formed and joined together simultaneously by conventional double layer weaving or double layer knitting methods.

At least one of the sheets has at least a portion which is gas permeable. The permeability of the sheet is chiefly due to the pores between the fibres (e.g., in the threads) which make up the sheet. Preferably, the permeability is within the range from 0.1 to 1000 $dm^3/m^2/s$, more preferably 1 to 100 $dm^3/m^2/s$. Typically, the whole of the sheet, where not adhered to the other sheet in the double layer, will be gas permeable. However, when used in the device of the invention, the sheet may be treated or joined to the other sheet such that only a portion of it is gas permeable. The degree of permeability of the sheet after it has been formed may be suitable for many applications and it may not therefore require further treatment. However, if the permeability of the sheet needs to be reduced for a given application, this can be achieved by treating the sheet such that a proportion of the pores between the fibres become partially or completely blocked. Blocking of the pores in this way may be carried out by methods which are well-known in the art such as treatment with an aqueous dispersion of a polymer (e.g., PVC, polyacrylate or polyurethane) or transfer coating with a permeable polymer film.

Preferably, one of the sheets is gas permeable and the other is substantially impermeable. Such an arrangement has the advantage of allowing gas to be delivered from all (or part) of one face of the double layer sheet only. The ability to direct gas in this way is a clear advantage of the invention. The sheet which is substantially impermeable may be formed initially in the same way as the gas permeable sheet and subsequently treated with a material which renders the sheet substantially impermeable. Treatments to render the sheet impermeable include, for example, coating the sheet with an impervious coating of a polymer (such as a film of polyurethane, polyethylene or polypropylene) which may be applied to the sheet using an adhesive either directly or indirectly by transfer from a release paper. Alternatively, the substantially impermeable sheet may be formed separately from the permeable sheet and may be made substantially impermeable by increasing the density of the fibres in the fabric and/or reducing the size of the pores.

At least a part of the region between the sheets in

the double layer may be inflated by gas directed through the inlet. Inflation of the region, which has a limited permeability, causes a back pressure to the gas supply and ensures that the delivery of gas from the device is substantially uniform throughout the whole of the part of the gas permeable sheet or sheets which bound the inflated region. It also allows the device to act as a cushion for an article which is placed on or near to the surface of the device. The sheets may be made resiliently deformable by, for example, the use of a proportion of elastomeric fibres such as Lycra[R], but this is not essential for the operation of the invention.

The device comprises an inlet for gas which directs gas to the region between the sheets. Gas may be supplied by any means of providing gas at a pressure greater than atmospheric pressure such as a compressor or a cylinder of pressurised gas. If the device has more than one gas delivering region, the inlet may comprise a manifold arrangement for directing gas from a single supply to each of the gas-delivering regions of the device.

The nature of the gas which is delivered by the device will depend on its intended use. The gas may consist of a single element or compound or may comprise a mixture of two or more elements or compounds. Reactive gases (such as hydrogen or the halogens) may be provided into the liquid phase of a chemical reaction. Alternatively, the device may be used to supply relatively inert gases (such as argon and the other noble gases, carbon dioxide or nitrogen) to provide an inert gas atmosphere. Gases might also be delivered to plants to control their growth or their ripening e.g., carbon dioxide which can speed up the growth rate of plants such as tomatoes.

In another application, the device of the invention may be used in a spurge system for the scrubbing of air. Soiled air is pumped into the device by way of the gas inlet, with the device being present within a tank of aqueous cleansing solution. The air permeates out of the device as a fine dispersion of bubbles enabling efficient cleansing of the air by the cleansing solution.

The device may also be used to regulate the temperature of an article or a region by a method which comprises delivering gas of a predetermined temperature. For this application, the gas is preferably air. A particular application of the device is in maintaining comestible products (such as packaged or unpackaged foodstuffs) at a temperature below room temperature (e.g., -10 to 10°C). Conventionally, the transport of comestible products within a food processing or packaging facility, for example on a conveyor belt, has caused difficulties since it has been necessary either to transport the products quickly through an area which is at room temperature (which may be undesirable as regards the perishability of the product) or to keep the whole of the area at a reduced temperature (which is undesirable for an area in which people need to work). The device of the present invention overcomes these problems since it allows cold air to be supplied directly to the product and its immediate surroundings and therefore need not significantly affect the environment outside this zone. Since the device of the invention can be made light and flexible, it may itself form the conveyor belt on which the food is transported. Alternatively, one or more than one of the devices of the invention can be disposed above a conventional conveyor belt to direct cold air at the product. The device or devices may also be disposed above or below a conveyor belt which allows air to pass through it by, for example, being made from a chain-type arrangement. The device has the advantage of greatly reducing the tendency for moisture from the surrounding warmer air to condense onto the foodstuff or its packaging.

Another example of temperature regulation using the device of the invention is in the delivery of relatively warm or cold air directly to the human or animal body by making a garment comprising a device of the invention with the gas permeable sheet facing the skin.

The device of the invention, in one preferred embodiment, is a double layer of the sheets, sealed at its edges and having an inlet for gas to allow gas to pass into the device and between the sheets. In use, gas passes through the inlet and inflates the region between the sheets. The gas permeates through the permeable sheet or sheets and the pressure of the gas coming into the device at the inlet is then adjusted to achieve a steady state i.e., a substantially constant rate of flow of gas into the device and rate of flow of gas out of the device. The sheets may be kept substantially parallel, when inflated, by means of monofilaments between the sheets which can be included when the device is manufactured, using conventional technology.

In another preferred embodiment of the invention, the device is formed from two sheets of fabric with alternate bands of the sheets being joined together (for example, either by being woven, sealed or adhered to each other) and being unconnected, along or across the direction of production of the fabric. The regions in which the sheets are unattached are connected to an inlet for gas at one edge of the sheet and are sealed at the opposite edge (again, for example, by being woven, heat sealed or adhered to each other). When gas is passed through the inlet into the device, the unattached regions inflate to provide a structure which resembles a series of connected parallel tubes. In a variation on this embodiment of the invention, a proportion of the unattached regions (for example, every other region) may contain a substantially rigid material, such as foamed rubber, to provide extra support for an article placed on the device. Alternatively, a proportion of the unattached regions may contain a porous material, such as an open cell foam. The use of a porous material allows gas at a reduced pressure to be connected to these unattached regions of the device, preferably by means of a non-collapsible tube (i.e., a tube which will not collapse under the reduced pressure) with apertures along its length

which extends through the centre of the porous material, and thereby permits at least a proportion of the gas emitted from the device to be recovered (and, possibly, recirculated) by being drawn back into the device by means of the reduced pressure. This arrangement also has the advantage of reducing the tendency of the gas delivered from the device to diffuse away from its surface and into its surroundings.

Preferred embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings wherein:

Figure 1 shows a perspective view of a device according to one embodiment of the invention;
Figure 2 shows a perspective view of a cross-section through a device according to another embodiment of the invention;
Figure 3 is a plan view of the device shown in Figure 2;
Figure 4 is a perspective view of a cross-section through a device according to yet another embodiment of the invention; and
Figure 5 is a perspective view of a cross-section through a device according to a further embodiment of the invention.

Referring to Figure 1, device 1 has a main body 2 which is attached to gas inlet 3. Gas inlet 3 allows gas to be passed into the interior of main body 2. Main body 2 comprises an upper sheet 4 and a lower sheet (not shown) of woven, knitted or non-woven fibres. Upper sheet 4 and the lower sheet are joined at their edges by four side walls 5 (only two of which are shown), and, optionally, internally by monofilaments, which may be made from the same material (or a different material) from the upper sheet 4 and the lower sheet. Side walls 5 can be made impermeable by, for example, heat fusing or applying an impermeable film of a polymer or a sealant. In use, gas is passed into main body 2 through inlet 3 to inflate the main body. The term inflation, as used throughout the specification, means that main body 2 of device 1 is reversibly (and generally outwardly) deformed by the pressure of the gas within main body 2 such that the pressure of the gas within main body 2 is higher than the pressure outside main body 2. Gas permeates through upper sheet 4, and also from the lower sheet if this too is gas permeable (although it need not be), and reaches a steady state when the gas permeates out of main body 4 at the same rate at which it is added via inlet 3. Device 1 permits the delivery of gas in a direction away from upper sheet 4 (and also from the lower sheet if it is gas permeable) in substantially only a single direction allowing it to be directed towards an article or region in the vicinity of device 1. Maintaining the sheets substantially planar and parallel, using monofilaments, further restricts the flow of gas to a single direction.

In Figure 2, device 6 has an upper sheet 7 and a lower sheet 8. Upper sheet 7 and lower sheet 8 are joined at regions 9, for example, either by adhesion of sheets 7 and 8 or by sheets 7 and 8 being heat sealed, woven, knitted or stitched together. In the regions 10 where the sheets are unjoined, gas pressure within device 6 (supplied from a gas inlet which is not shown) inflates regions 10 to give them a tubular shape. Gas permeates out of upper sheet 7. In this embodiment, lower sheet 8 is made substantially impermeable by a coating 11 (for example, of a polymeric substance) which is applied thereto such as by adhesion using a suitable adhesive. Thus, the gas permeates substantially only out of upper sheet 7.

Figure 3 shows device 6 of Figure 2 to illustrate how gas is directed to regions 10. An inlet 12 for gas comprises a hollow tube in the form of a manifold, which may be rigid or deformable, and which has an opening 13 through which the gas is directed. Regions 10 and inlet 12 have common openings 15 which allow the passage of gas from inlet 12 into the regions 10.

A variant of device 6 shown in Figures 2 and 3 is illustrated in Figure 4. In this embodiment of the invention, alternate regions 10 contain supports 14. Supports 14 are of resiliently deformable material (such as foamed rubber) and provide support for an article placed on device 6; this is particularly important when a heavy article is placed on device 6 since the gas pressure may be insufficient to allow regions 10 to support the article and, without supports 14, regions 10 may collapse under the weight of the article.

Another variant of the device 6 of Figures 2 and 3 is shown in Figure 5. In this embodiment, the device 6 resembles that of Figure 4 with supports 16 in alternate regions 10 of device 6. However, supports 16 are porous (being made, for example, of open cell foam) and have hollow centres 17 through which insert tubes 18 pass. Insert tubes 18 are perforated along their length, although this is not shown in the Figure. Insert tubes 18 may be connected to a source of reduced pressure by means which are not shown. The reduced pressure causes gas to flow through upper sheet 7 and support 16 and into insert tube 18 by way of the perforations in insert tube 18. This flow of gas into the device 6 occurs throughout the length of the upper sheet 7 which is adjacent to supports 16. Thus, at least a proportion of the gas emitted from regions 10 is recovered and may be recirculated, allowing a reduction in the overall cost of the process. This arrangement has the further advantage that the gas delivered from device 6 flows out from regions 10 and back into insert tubes 18 setting up a pattern of gas flow which reduces the tendency of the gas to diffuse away from the immediate vicinity of device 6.

The following non-limiting example illustrates, by way of example only, the construction of a device according to the invention.

EXAMPLE 1

A 436 g/m^2 plain weave double layer woven fabric of nylon fibres in continuous filament yarns (weft - 940 dtex/140 fil. flat nylon 66 from Akzo (Holland) grade 155 HRST high tenacity heat resistant bright; warp - 470 dtex/72 fil. 130Z TPM Akzo nylon 66 444 HRST) was produced as a 25cm x 25cm sheet with a solid woven section of 5cm width joining the sides of each layer.

A coating of a soft aliphatic polyurethane dispersion (Witcobond^R 290H supplied by Baxenden, Droitwich, UK) of viscosity 6,960 mPas (6,960 cps) (Brookfield Apparatus, spindle no. 4 at 10 rpm) was applied to one of the layers. The coated fabric was dried and cured at 160°C. The resulting coated surface had a porosity of about 10 dm^3/m^2/s.

The uncoated layer was then made impermeable. An impermeable film of polyurethane of 72 g/m^2 weight and a gauge of 50μm (50 micron Tuftane^R supplied by Lord Corporation, Manchester, UK) was coated with a soft polyurethane adhesive paste (Witcobond 290H viscosity adjusted using Myrox^R HP from Stockhausen UK, Milton Keynes, UK) of viscosity 57,600 mPas (Brookfield Apparatus, spindle no. 4 at 1 rpm) using an annular grooved rod (knife over air system) or by knife over roller to give a coating of adhesive at a level of about 20 g/m^2. The uncoated layer was then brought into contact with the adhesive-coated face of the polyurethane film whilst the adhesive was still wet and subjected to heat to form a bond between the layer and the film.

The double layer of fabric was then sealed around three of its sides by heat fusing the edges or by applying a silicone sealant. A flexible air supply tube was then inserted into one edge of the double layer and sealed to the fabric using a silicone sealant.

Compressed, refrigerated air was pumped into the device at a pressure of 200 Pa (DIN 53887-200cm^2 test area) to inflate it. A fine dispersion of chilled air issued from the porous face of the fabric at a rate of about 10 dm^3/m^2/s. Food items placed directly above the porous face of the fabric were chilled without a significant reduction in the temperature of the working environment. Maintaining food items at a low temperature in this way also greatly reduced the tendency for water to condense on the food from the surrounding warm air.

Claims

1. Gas delivery device comprising an inlet for gas and two sheets of woven, knitted or non-woven fibres arranged as a double layer, at least one of said sheets having a portion which is gas permeable and the sheets being joined such that at least a part of the region between the sheets is capable of being inflated by gas directed through the inlet and, when inflated, of allowing the gas to permeate out of the device through the gas permeable sheet or sheets.

2. Device as claimed in claim 1, wherein one of the sheets is at least partly gas permeable and the other is substantially impermeable.

3. Device as claimed in claim 1 or claim 2, wherein the sheets comprise a fabric of woven fibres.

4. Device as claimed in claim 2 or claim 3, wherein the permeability of the sheet which is at least partly gas permeable is reduced by coating with a polymer dispersion.

5. Device as claimed in any one of claims 1 to 4, wherein the two sheets are woven as one fabric.

6. Device as claimed in any one of claims 1 to 5, wherein the sheets comprise joined regions at which the sheets are joined and unconnected regions which are capable of being inflated by a gas.

7. Device as claimed in claim 6, wherein the joined and unconnected regions are arranged as regularly spaced bands along the double layer.

8. Device as claimed in claim 7, wherein a proportion of the unconnected regions contain substantially rigid material.

9. Device as claimed in claim 7, wherein a proportion of the unconnected regions comprise a substantially rigid porous tube, the interior of the tube being capable of connection to gas of reduced pressure.

10. Method of delivering gas comprising providing the gas from a device according to any one of claims 1 to 9.

11. Method as claimed in claim 10, wherein the gas is of a predetermined temperature such that it regulates the temperature of its surroundings.

12. Method as claimed in claim 11, wherein the gas is at a temperature below room temperature.

13. Method as claimed in claim 12, wherein the gas is delivered to a comestible product.

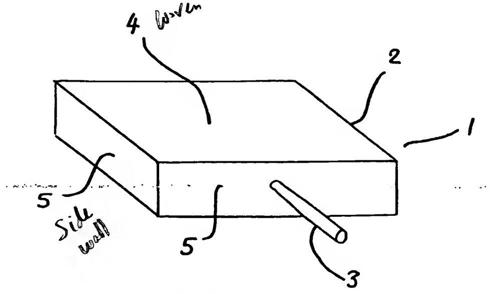
4 woven
2
1
5
Side wall
5
3

FIG. 1

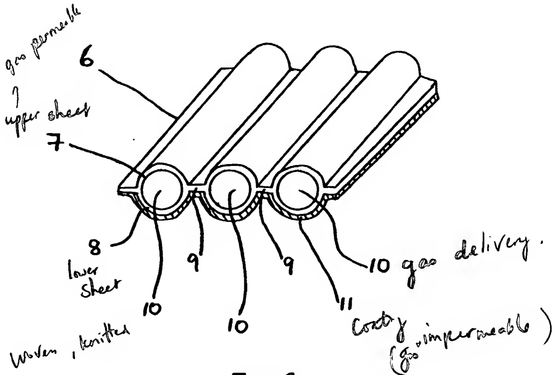
gas permeable
upper sheet
6
7
8
lower sheet
9
9
10 gas delivery.
10
10
11
woven, knitted
Coating
(gas impermeable)

FIG. 2

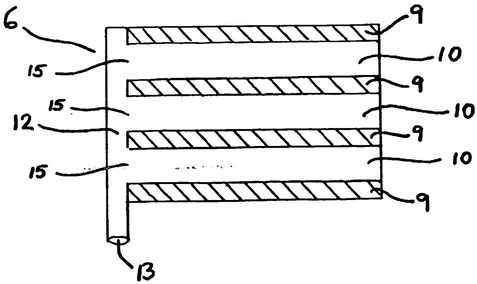

FIG. 3

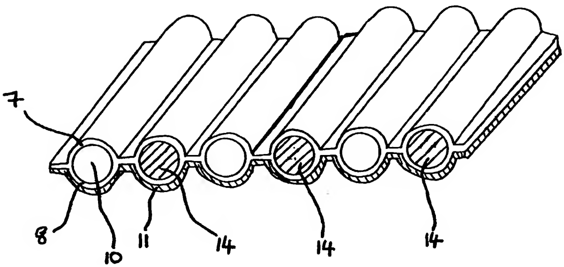

FIG. 4

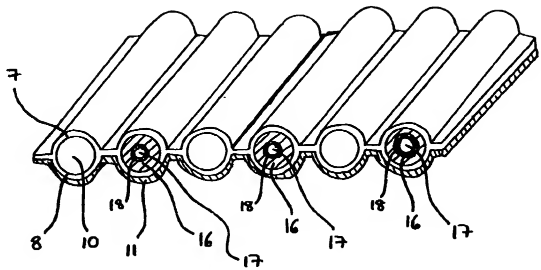

FIG. 5